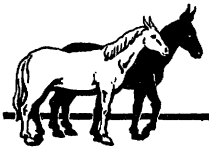
Improving Horses and Mules



By J. O. Williams, Senior Animal Husbandman, and William Jackson, Associate Animal Husbandman, Bureau of Animal Industry

THE breeding of horses is an art that goes far back in history. No animal, with the possible exception of the dog, has had so much affection and respect from man as the horse, and it is safe to say that few possessions are more cherished than a fine horse. The desire to breed better animals has been correspondingly strong, and much lore about horse breeding has developed during many generations. For reasons that will be made plain in this brief survey, however, the new science of genetics has as yet achieved little in this field. No attempt is made here to record the history of horse breeding, but only to sum up certain aspects of the situation from the scientist's viewpoint.

In order to show what progress has been made in the fixation of inheritance for various characters in horses, the cooperation of each State agricultural experiment station was asked to obtain certain breeding information on outstanding individuals and studs. The points upon which data were requested included: For draft breeds—plan of breeding, services per mare and foals produced, weight at birth, measurements at birth, ages when subsequent measurements are taken, height, temperament, action, muscling, strength, stamina, symmetry of conformation, feed consumption, and soundness; for light breeds—plan of breeding, services per mare and foals produced, weight at birth, measurements at birth, when subsequent measurements are taken, height, temperament, action, symmetry of conformation, speed, gaits, length of neck, slope of shoulder, length of pastern, shape of foot, set of legs, quality of bone, and soundness. In addition each station was asked: (1) Whether a progeny-testing method was used; (2) to submit a list of horse-breeding project activities; and (3) to submit names and addresses of owners of studs having a reputation for developing superior breeding stocks. With this information it would be possible to summarize the research achievements in the field of horse breeding as a background for the development of well-rounded plans for further investigation.

The Status of Scientific Work on Inheritance in Horses

THE questionnaires indicate that 18 States are doing no work in horse breeding, while 21 States maintain studs, usually for classroom work. Percherons were found in most of these, Belgians in many of them, Clydesdale and Thoroughbreds each in two, and Arabian horses in one. Nine States made no report.

Few of these States have experimental projects that involve a distinct genetic approach to horse breeding. The work being done either concerns the physiology or pathology of reproduction in connection with college work, or the recording of limited data. Colts are weighed at birth and at more or less regular intervals thereafter. A few stations record height at withers and some record heart girth (circumference of chest), circumference of fore and hind cannon bones, color, markings, and such data as mating and foaling dates and feed and work records.

Much more is known, of course, about the horses in a stud than is indicated in the recorded data. Many of them are studied and judged critically by classes in animal husbandry, and the peculiarities of their form, action, and temperament are known to instructor and student.

A few stations conduct experiments aimed largely at finding out the cost of producing colts. Such stations record feed consumption and other costs, but primarily for the information this will give on management methods. Also, some stations reported records that yield information about the breeding efficiency of their stallions and mares. On the average, two services are required for each colt produced.

A BRIEF REVIEW OF RESEARCH IN HORSE BREEDING

A survey of the literature reporting current and recent research work with horses reveals a considerable number of experiments on the physiology of mating and reproduction, particularly in the United States, Great Britain, the Union of Soviet Socialist Republics, Germany, France, and Japan; several experiments for improving technique in the practice of artificial insemination; a few studies of the inheritance of color; an occasional one attempting to correlate body measurements or other factors with constitution and performance; and one study of blood groups in the horse and their inheritance.

Hart and Cole (*10*)[1] of the California Agricultural Experiment Station have developed a method for diagnosing pregnancy in mares as early as 42 days after breeding that is sufficiently practical for use by stables where intensive breeding of valuable horses is being done. By its use it should be possible greatly to reduce the uncertainty and waste of time in establishing whether a mare has been successfully bred. It should also be valuable in obtaining an early indication of a new stallion's ability to get foals. Other workers (*8, 9, 13, 15*) have made additional contributions to that of Hart and Cole.

[1] Italic numbers in parentheses refer to literature cited, p. 945.

Two workers (*2*) of the Union of Soviet Socialist Republics demonstrated that gravidan, a hormone obtained from the urine of the pregnant mare, is of practical use in inducing ovulation in mares that have previously failed to come into heat or refused to accept the male.

Eickman (*6*), in Germany, estimated that of 20,000 mares served in the Rhine Province during 1934, as many as 8,000 required treatment for sterility. In approximately 1,000 tests for diagnosis of pregnancy—blood tests from the forty-ninth to the one hundred and

FIGURE 1.—The versatile American farmer is learning to use his horse power in larger units to save man labor and perform the heavy operations on farms such as plowing. This is an eight-horse hitch pulling a three-bottom gang plow. A horse must have the proper temperament to work well in the various types of hitches.

fiftieth day and urine tests thereafter—the percentage of error was 0.9; while 39 percent of the sterile mares yielded to treatment and foaled.

An attempt to measure racing capacity in the Thoroughbred horse has recently been made by Laughlin (*14*) of the Carnegie Institution of Washington, and after several years' work on the problem he has devised a basic formula by which racing capacity may be measured

within certain limits, and mathematical rules that apparently govern its inheritance.

Stone (*19*) of Stanford University, after weighing many lines of evidence, advanced the belief that male Thoroughbred horses as a class surpass the females of that breed in running ability, and that the best of the females are inferior to the best of the males in this respect.

Müller (*17*) in Germany found, after extensive study, that chest length, width, depth, and girth measurements do not give an indication of performance in terms of speed and endurance in horses, because they do not reliably indicate the volume of the thorax or of the vital organs located there. He found some indication of an interrelation in some of these factors—that chest length, for example, is greater in light and riding horses than in heavy draft-type horses.

In a study (*16*) of the significance of shoulder measurements in relation to running performance, Müller also summarized the results of some 20 others, adding a tabulation of his own of some 200 animals. He could find in shoulder measurements no reliable sign of running performance, and concluded that the systems of judging frequently recommended have no scientific basis.

Another German worker, Kaempffer (*12*), reports extensive studies of blood groups in the horse and their inheritance, and found it possible successfully to diagnose paternity in 22 cases out of 82 attempted, on the basis of new agglutinogens which he has demonstrated.

THE NEED FOR UNIFORM DEFINITIONS OF CHARACTER AND PERFORMANCE

On the whole, little definite knowledge exists on the genetics of the horse (*4, 18*), although he has been bred to greater variety than most other classes of livestock. For instance, coat colors in horses range through many combinations and a number of puzzling degrees of intensity not readily discernible or capable of being expressed in definite terms. In all breeds except the Suffolk, which must be chestnut, there are found most of the usual horse colors, which would indicate that most breeds are heterozygous for color and that most individual horses are heterozygous for one or more of the several genes having important effects on color. Furthermore, although speed and amount of work performed are readily measurable quantities, there is such a lack of satisfactory measures and expressions of a horse's will to perform to the maximum of his ability, the suitability of his nervous temperament for the duties demanded of him, and the part that his training may have played in influencing his inherited abilities, that the geneticist is greatly handicapped in his analysis.

These needs, together with the relatively high cost of the horse as experimental material and his slowness to reach maturity, have prevented finding very definitely what are the correlations between characteristics and performance.

Of cattle we demand meat and milk; of sheep, meat and wool. But of horses we ask power, versatility, speed, endurance, beauty of form and of action, courage, intelligence, and intuition in an amazing variety of combinations—hence the different types, conformations, weights, dispositions, and even colors to be found in the form of

horse flesh. The range runs from the plump, docile Shetland pony, or the harness pony 36 to 40 inches in height, weighing 500 pounds or less and possessing graceful, rhythmic action, to the ponderous draft horse standing 70 or more inches in height and weighing a ton and upwards.

For measuring speed and endurance we have the stop watch; for measuring tractive power, the recently perfected dynamometer; but for weighing many of the less tangible expressions of a horse's ability we must still depend on the judgment of the expert.

In the Thoroughbred and Standardbred, speed is of paramount importance and other characteristics are important only as they contribute to speed. In the saddle and heavy-harness types, beauty and grace of action are predominant requisites, being much more important than speed. In polo ponies and cow horses, agility, intelligence, and temperament have high value, and the rider cannot meas-

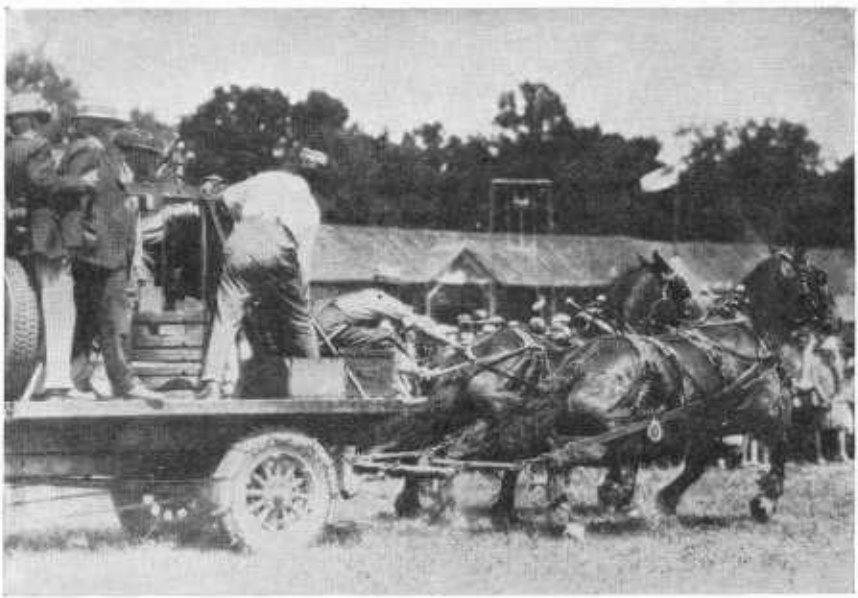


FIGURE 2.—The dynamometer, developed at Iowa State College, has provided a ready measure of the maximum pulling ability of horses. It does not of course measure a team's ability to pull moderate loads over extended periods of time and remain in good condition. Here is a heavy draft team under test.

ure them in absolute terms. Even for farm work in a country as varied in climate, topography, soil types, and cropping systems as ours, a wide range in combinations of weight, agility, and temperament is demanded of horses.

Soundness, good health, longevity, and the ability to reproduce are of course desired in all horses. Reproductiveness has received much attention from experimenters and breeders, and a considerable portion of the literature on breeding deals with reproductive troubles involving both sexes. The percentage of the colt crop is often low, yet there are records of extraordinary ability on the part of stallions to get foals.

Trueness of action is emphasized by breeders of horses of all types. Straight action and a good, energetic, free stride are desired because they are usually associated with efficiency. They indicate ability to

work at a rapid pace, and to give long service without lameness or undue fatigue. In addition, grace of action or "style" is essential in light horses ridden or driven for pleasure.

AMERICA'S CONTRIBUTION TO THE BREEDS

The outstanding and characteristically American breeds of horses developed in this country are the Standardbred or American Trotter, descended from a strain of the Thoroughbred breed in which speed at the trotting and pacing gaits is paramount; the American or Kentucky Saddle Horse, developed from the Thoroughbred with some infusion of Morgan inheritance, in which easy gaits under saddle and beauty of form have become characteristic; and the Morgan horse, also of Thoroughbred extraction, a type famous for stamina and sturdiness, developed in New England. At one time a type that fulfilled the requirements for an ideal cow pony, known as the "Quarter horse," was developed in the western range country, though it never reached the stage of recording pedigrees in a studbook. It got its name from the fact that it was very fast for short distances, up to a quarter mile.

No distinctly American breed of draft horse has been produced. The American breeder, however, has ingeniously adapted the predominant European breeds—the Percheron of France and the Belgian Draft of Belgium—to American conditions. Both breeds have been bred in this country to give more agility and a faster walk than the more ponderous European type. The latter is often used with a one-horse cart and is worked for shorter distances than horses usually travel in this country. The Clydesdale, Shire, and Suffolk breeds of Great Britain have also been imported and bred in considerable numbers in the United States.

Recently this Department has imported two stallions and four mares of the Nonius breed from Hungary. This breed is descended from a stallion of that name brought to Hungary from a State stud in France in the time of Napoleon. The original Nonius was by a Thoroughbred out of a Norman mare, and his descendants today are of two types—an upstanding, big-boned farm type, and a lighter type, described as "harder and better," which has made excellent records in Hungary in endurance and speed competitions. Both types are represented in the importation, and they will be used for breeding research.

Practical Measures That Look toward the Improvement of Draft Horses

PRACTICAL breeders and friends of the horse have not idled while the geneticists have been "calibrating their instruments." The colleges have trained students; extension services have promoted contests and demonstrations among farmers to illustrate the marks that can be made with the accuracy of sights now available; and horse and breeders' associations generally have been active in promoting the several breeds.

The most common measure of performance in draft horses has been the tractive dynamometer developed by Iowa State College for

testing maximum pulling power. Since 1923 it has been used at various fairs, horse shows, and special pulling events, and the data secured have been analyzed to determine what characters may be associated with pulling ability. Dawson (*5*) of Illinois found that the weight of the horse had more influence on pulling ability than any other factor studied. Heart girth is important chiefly as it reflects ability to maintain a heavy pull for some distance. Henderson and Ikeler (*11*) of Utah found that "sensible teams with great mental and nervous energy have been perhaps more successful than those of a quiet, easy-going nature." They found no correlation between body type and pulling power, citing as illustrations a champion heavy team that was upstanding and leggy, while the champion light team in the same contest was of the short-legged, heavy-bodied type.

Extensive studies at Iowa (*3*) of the maximum short pull and the less strenuous but continuous pull have shown that it is possible for horses to exert a tractive effort of one-tenth to one-eighth of their weight and travel a total of 20 miles a day without undue fatigue. However, for a short time it is possible for a well-trained horse to exert an overload of over 1,000 percent.

Much remains to be done to eliminate variables before critical studies can be made with the dynamometer. Horses should be given similar training before being tested; they should be made to pull singly; their condition of flesh and of health should be carefully recorded; and the footing and type of shoeing should be similar in all cases. Some measure of temperament, the relationship of temperament to momentum of pull, and of this in turn to pulling ability, should be agreed on. If the test is to have its greatest value, the breeding of all horses tested should be definitely known and recorded.

A demonstration of the value of breeding as well as of feeding and management in the production of draft horses has now completed 10 successful years in Indiana. It is known as the Hoosier Gold Medal Colt Club and is sponsored by Purdue University in cooperation with the Indiana Livestock Breeders' Association. Awards are made for outstanding individual colts and get-of-sire groups based on show-ring judgings, with a minimum requirement for gains in weight during the 12 months following weaning. The project began in 1926 with 96 members in 28 counties entering 137 colts. In 1935 a total of 936 members in 45 counties entered 1,273 colts.

An outgrowth of the work has been the scoring of the sires of the colts on the basis of the colts' achievements, with annual recognition of the high-scoring sire of each breed and of all breeds. This has resulted in virtually State-wide competition among breeding stallions based upon offspring performance, and has also extended general interest in breeding, in culling, and in get-of-sire competition.

There have been some outstanding achievements in consistent performance by winners in this competition. The junior champion Percheron stallion at both the 1935 Indiana State Fair and the 1935 International Live Stock Exposition represents the third generation of an unbroken line of winners in the project, while this stallion's dam, granddam, and great granddam each had a yearling in competition in 1935. For the Belgian breed, a mare, Lady Camille, herself a daughter and great granddaughter of champion stallions at the International, has two generations of consistent winners in Hoosier Gold Medal Colt Club competition and at major fairs and horse shows.

The project has resulted in clarification of aims and improvement in breeding and work stock among Indiana farmers, and has shown indications of a tendency for certain superior qualities to persist in some lines of breeding. Show-ring placing is, however, a relative matter rather than a definite measure of character expression and can be of little genetic value as it is at present determined and regarded. The situation in this respect is no worse for horses, however, than it is for many other classes of animals shown extensively in the ring.

Horse breeding naturally lends itself to community effort since one stallion will suffice for the service of mares owned by several breeders. This has both advantages and disadvantages for improvement. One disadvantage is that the owner of the stallion standing for public service frequently has little immediate interest beyond the service fee. It would be well to have some control of the breeding qualities of such sires to prevent undesirable heredity from being widely distributed. A movement for such regulation and licensing of public-service sires was inauguarted by the State of Wisconsin in 1906. Today, 22 States have such laws, though there is a distinct lack of uniformity in their construction. This is manifested, for example, in the varying definitions of unsoundness. A clarification and general agreement on the specific types of unsoundness that are hereditary would assist materially in adding effectiveness to these statutes.

A total of 13,753 stallions, of which 9,666 were classified as purebreds, were licensed in 1934 under these State enrollment laws, and since in many instances the stallions are under the close scrutiny of active secretaries of the enrollment boards, the sires outstanding on the basis of apparent performance are probably known to some extent.

Improvement in Light Horses—A Notable Record Difficult to Interpret

IN THE light-horse industry, particularly in those branches of it associated with sport, there is a vast amount of earnest and privately endowed effort to produce and locate superior germ plasm, most of it by the well-known trial-and-error method of breeding the "best" to the "best" and hoping for the best. There has been little success in establishing definite relationships between form and other characters and performance. On the one hand is the highly accurate, electrically controlled measure of elapsed time; on the other, the immeasurably variable impressions that can reach man's brain through the retina of his eye and be cataloged there.

Even with a wealth of facts and ingenious instruments at his disposal, the geneticist has a job ahead of him. But it is also generally admitted that the breeder already has achieved some handsome results by trial-and-error methods.

An important project in light-horse breeding, known as the Military Horse Breeding Project, was inaugurated by the Bureau of Animal Industry of the Department of Agriculture in 1912. It was developed for several years in cooperation with the War Department

and transferred to that Department in 1920. It is now supervised by the Remount Service of the Quartermaster Corps and is the instrumentality for distributing approximately 700 stallions of the light breeds, principally Thoroughbreds, for public service. These stallions are located throughout 38 States, Puerto Rico, and Hawaii. Table 1 lists the stallions assigned to agents in the field for public service but does not include stallions at remount depots:

TABLE 1.—*Stallions assigned to field agents for public service and breeding results, 1931–34*

Year	Stallions at stud	Mares bred	Foals produced
1931	630	16,500	9,900
1932	638	16,600	9,960
1933	678	18,300	10,980
1934	691	17,100	(1)

[1] Data not assembled.

Another breeding project of unique character was founded at the United States Morgan Horse Farm, near Middlebury, Vt., in 1907 when Joseph Battell, a lifelong admirer of Morgan horses, presented the Department of Agriculture with a tract of 400 acres to be used as a center for concentrating the best Morgan blood and preventing the extinction of this once popular breed. From this farm, which has been enlarged to about 1,000 acres, hundreds of Morgan breeding animals have been distributed to all parts of the Union and of the world. The farm maintains a stud of about 60 animals.

An interesting series of record-of-performance tests for different breeds and types of horses intended for cavalry use was the "endurance rides" sponsored by various horse associations. These tests were conducted from 1919 to 1926. The distance of the annual tests was 300 miles, and the awards were made on a basis of 60 percent for condition of the horses that finished and 40 percent for speed.

The records obtained were principally body and leg measurements, though the horses were closely observed while in the 5-day test and notes were made of their performance, including respiration, pulse, length of stride, evidence of fatigue or lameness, and appetite. A brief summary of these tests is given in table 2.

TABLE 2.—*Summary of records of endurance rides, 1919–26*

Breed	Horses starting	Horses finishing		Average height	Average weight	Horses having leg trouble		Percentage of own weight carried	Speed per hour
	Number	*Number*	*Percent*	*Hands*[1]	*Pounds*	*Number*	*Percent*		*Miles*
Arabian	14	7	50	15	860	2	14	26	5.4
Do.[2]	11	8	73	15	954	4	36	24	5.7
Thoroughbred	22	9	41	16	1,024	18	62	23	6.5
Do.[2]	46	21	46	16	1,060	33	72	21	6.3
American Saddle	7	3	43	16	1,000	4	57	23	6.6
Morgan	23	11	48	15	918	10	42	25	6.0
Do.[2]	13	5	38	15½	1,036	7	54	22	6.3
Anglo-Arab	9	3	33	16	1,000	5	56	23	6.5
Standardbred	3	0	0	15	900	1	33	25	5.3
Total	148								

[1] 1 hand equals 4 inches.
[2] Grade.

RECORDS OF SPEED PERFORMANCE

The first extensive records of performance for any farm animal were the speed records of the Thoroughbred horse, which go back in one form or another for 200 years.

The history of trotting-horse racing in the United States dates back over a period of 130 years, and for more than 50 years Wallace's Trotting Register has recorded speed records for the Standardbred.

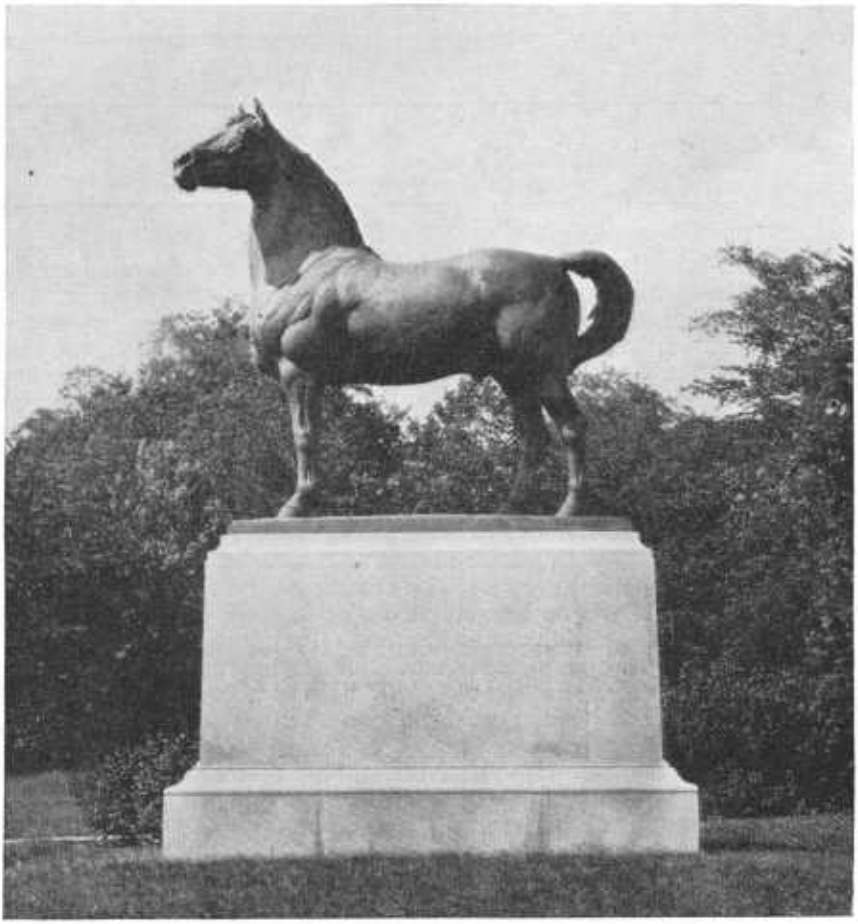


FIGURE 3.—In honor of the progenitor of a famous breed of American horses—the Morgan. A statue of Justin Morgan donated by the Morgan Horse Club of America and erected in 1921 on the United States Morgan Horse Farm, Middlebury, Vt., on the 100th anniversary of his death.

A century and a quarter of trotting records shows a consistent improvement in speed, although it is impossible to determine what part of this can be credited to superior inheritance for speed.

It is recorded that in 1806 a horse named Yankee was the first to cover the mile distance in less than 3 minutes, trotting. His time was 2:59, which he reduced to 2:49½ in 1810. These races and others at that time were done under saddle, and it was not until the 1840's that the first authentic instance of trotting to a sulky was recorded.

This was at Boston, Mass., where the mare, Lady Suffolk, was credited with the first mile record under 2:30.

Gradually the record crept downward, and it had reached 2:08¼ when, in 1892, the high-wheeled sulky was replaced by the modern, pneumatic-tired racing sulky. In 1903, at Readville, Mass., with this equipment and lighter harness, Lou Dillon finally achieved the 2-minute mark. Since that date about 20 trotters have raced a mile in 2 minutes or less. The best trotting record to date is 1:56¾ made by Peter Manning against time in 1922.

The first 2-minute mile by a Standardbred pacer was recorded by Star Pointer in 1897, and some 30 pacers have equalled that mark or bettered it since. The present record of 1:55 was set by Dan Patch in 1906—preceded by a runner to sulky carrying a windshield.

FIGURE 4.—Testing horses for endurance. A scene on one of the endurance rides which were sponsored by several organizations interested in the improvement of saddle horses for remount purposes.

It is interesting to note that the rules for admission of Standardbred horses to registration, as originally established in 1879, are quite different from those used in other classes of livestock. Performance was given equal weight with pedigree as the open sesame to registration, and studbook entry was allowed to individual animals on the basis of speed performance—their own or that of their progeny—regardless of breeding. In effect, such rules threw great emphasis on individual selection, based on performance and progeny test, in comparison with the usual livestock registration rules, which put the emphasis primarily on pedigree—in one sense exclusively, since animals without proper pedigree can never be admitted.

These original rules also allowed registration to animals whose pedigree showed 75 percent of Standardbred blood, even without an approved speed mark. This provision was dropped for horse colts

in 1887. In that year, and again in 1891, 1892, 1893 (effective in 1895), 1898, and 1930, revisions were made in the requirements for Standardbred registration, with a gradual tightening until, effective January 1, 1933, registration on the basis of performance alone was no longer granted. Today a Standardbred horse, to be eligible to registry, must be by a registered sire out of a registered mare.

Of chief interest, perhaps, is the fact that throughout the long period when admission to Standardbred registry was available to the grade or cross-bred animal who could, either itself or through its progeny, equal certain speed standards, such grades and cross-breds generally were unable to make the goal. For a third of a century and more the increasingly rigid performance standards that have been set for Standardbreds have operated as an effective barrier to all animals not carrying an overwhelming percentage of Standardbred blood in their immediate ancestry.

The improvement in record-making performance has been undeniable. It would be extremely difficult, however, to attribute any definite portion of it to the segregation of superior germ plasm. Better management, faster vehicles, lighter and improved harness, faster tracks, and sampling from greater numbers of animals have also been factors. On the other hand, of twenty 2-minute trotting records and thirty 2-minute pacing records achieved in a period of nearly 40 years, 13 trotting and 18 pacing records have been made in the past 15 years when fewer Standardbreds have been in use than formerly. Moreover, it is rather generally agreed by harness-horse owners and observers that 2- and 3-year-old trotters and pacers now commonly set marks that would have been prized by older horses a few years ago running under essentially the same conditions. This would seem to indicate an improvement in average excellence at least.

HOW GREAT SIRES CARRY ON THROUGH THEIR PROGENY

American horse-breeding annals do, however, offer convincing records of the ability of great sires to "carry on" through their progeny. Of all such examples, especially when viewed from the standpoint of their influence on a breed, none is more significant than the contribution of Hambletonian 10.

This famous Standardbred sire, a son of Abdallah and a descendant of the imported Thoroughbred stallion Messenger, was foaled in New York State in 1849. During his lifetime he is reported to have sired more than 1,300 foals; through one period of 7 years (1860–66) he got 714 colts from matings with 1,027 mares, an average of more than 100 foals a year. In 1865 the price of his service was $300, and he covered 193 mares. In 1866 the price was advanced to $500, and he served 105 mares. In 1870, when he was 21 years old, he covered 22 mares and got 13 foals. He got two foals in 1875 and died the following March.

Hambletonian 10 was one of the greatest horses that ever lived, when measured by offspring performance. He was photographed at rest and in action, and every known measure was used to discover the secret of his greatness. It took more than a thousand words to pen a reputedly accurate description of him that has itself been

subjected to much intelligent and critical review and amendment. He had contradictory points of conformation and character that puzzled the wisest. According to Wallace (*20*), "his two great, meaty ends, connected with a long and perfect barrel, two or three sizes too small for the ends, showed such a marked disproportion that I often wondered at it." The horse's ears were so set that they habitually lopped backward when he was in repose, there was an abrupt, entirely unorthodox, angle to his hocks, and his stride was so much his own as to be termed peculiar, yet when he settled into it there was a supple, frictionless beauty of movement.

Hambletonian 10 laid the foundation for the trotting-horse breed. The ability to transmit harness racing speed did not pass away with him, for other great sires have followed. Two of the most noted of these in modern times are Peter the Great and Guy Axworthy, both descendants of Hambletonian 10. Peter the Great died in 1922, aged 27 years. In volume 44 of Wallace's Year Book (*1*) he is credited with 498 trotters and 163 pacers of standard record, which is 2 minutes 30 seconds for the former and 2 minutes 25 seconds for the latter, for the mile distance. He is also credited there with 172 sons which have themselves sired one or more animals with the required standard speed, while his daughters have foaled 550 trotters and 149 pacers with such records.

Where Peter the Great left off, his sons are carrying on. Three sons alone, Peter Volo, Chestnut Peter, and Azoff, are credited up to 1932 with 520 trotters and 167 pacers with standard speed records. Moreover, these three sires, up to 1932, had 151 trotters and 71 pacers in the 2:10 list.

By the close of the 1931 season, Guy Axworthy had sired 421 trotters and 40 pacers of standard record. He also had to his credit 49 sons which sired standard-record performers, while his daughters produced 186 trotters and 37 pacers with acceptable speed records for this standard.

Measured by more exacting standards, these two great sires continue to demonstrate their ability to hand on their good qualities. In the 2:10 list, Peter the Great has sired 111 trotters and 48 pacers. He sired one pacer in the 2-minute list and the dams of three 2-minute trotting performers. His son, Azoff, sired the world champion trotter, Peter Manning, 1:56¾; and Peter Volo, another son, has four entries in the 2-minute trotting group.

Guy Axworthy, in the 2:10 list, has 143 trotters and 13 pacers; in the 2-minute list, 4 trotters. His four sons that are 2-minute performers or better are: Lee Axworthy, 1:58¼; Guy McKinney, 1:58¾; Mr. McElwyn, 1:59¼; and Arion Guy, 1:59½.

To illustrate the influence of a great Thoroughbred sire which transmitted heredity for many of the characters influencing speed, the record of Domino is cited (*7*). This stallion died at the early age of 6 years after only two seasons in stud, and produced only 20 foals, 6 born in 1897 and 14 in 1898, yet the name of Domino in direct male line is found in the pedigrees of such great performers of today as Balladier, Black Helen, Boxthorn, Equipoise, Mata Hari, Observant, and Riskulus.

The Mule—An Outstanding Example of the Practical Use of Hybrid Vigor

THE mule is the classic example of the deliberate and widespread use of hybridization for producing stock in which vigor is an important consideration. The cross has shown consistently uniform results. From its horse ancestry it inherits substance and size, and to some extent alertness. From its ass ancestry it gets its steady-going qualities, sure-footedness, and the ability to withstand long

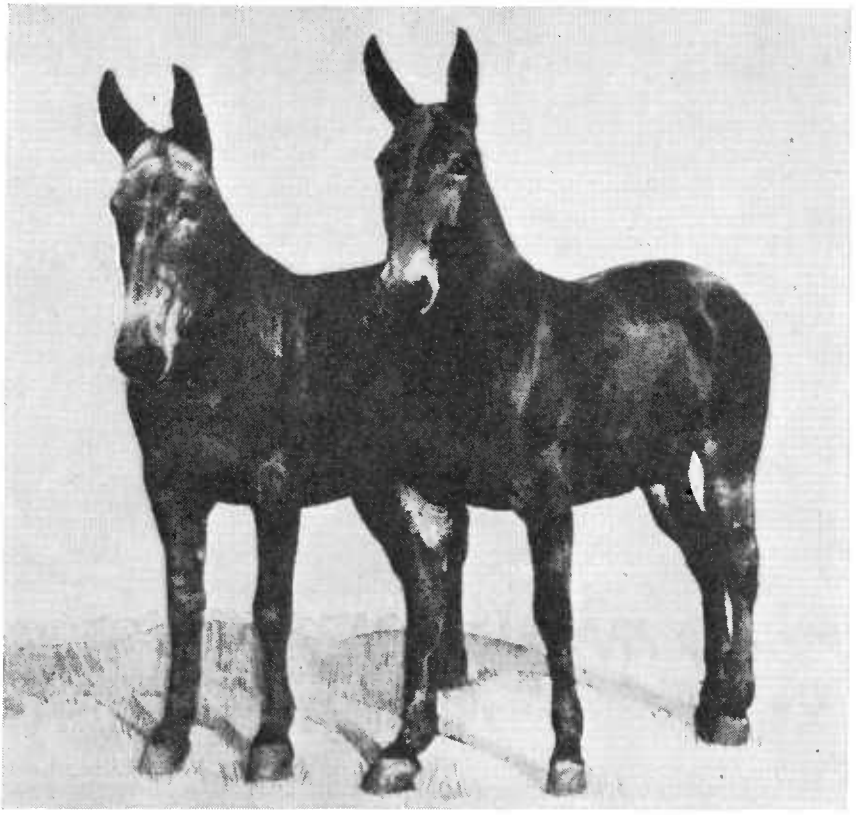


FIGURE 5.—Our hybrid servants—mules—have no "pride of ancestry or hope of posterity" but the breeding of "superior" jack stock and the availability and selection of proper types of mares is a splendid field for reasearch by our experimentalists.

periods of hard labor in hot climates, in mines, and under similar adverse conditions.

In the United States one of the earliest and most influential sponsors of the mule was George Washington. In 1785, a jack and two jennets of the Andalusian breed, gifts from the King of Spain, arrived at Mount Vernon. This was the first recorded jack-stock importation in American history. Later Washington received a Maltese jack and

jennet from the Marquis de Lafayette. Washington bred the Maltese jack to an Andalusian jennet. The progeny, which he named Compound, was the first "all-American" jack. This jack sired some excellent mule stock, and the value of the mule as a work animal was soon recognized by the early planters.

It is only within the last half century, however, that the production of mules has become an extensive enterprise. Mule breeding is carried on mostly in Texas, Missouri, Oklahoma, Tennessee, Kansas, and Kentucky. These States, together with Illinois, Iowa, and Arkansas, raise about 75 percent of all mules in the United States. Mules are used most extensively in the Cotton Belt States.

For some purposes, such as work in the sugarcane sections, heavy draft mules are desired, but the development of the truck and tractor has in recent years brought severe competition in this work. As a result, the market preference for large mules is not so strong as it used to be, although it still exists. The heavy draft mules are produced from mares of draft breeds, principally Percherons and Belgians, and the smaller mules from mares of the light breeds and types that carry considerable Standardbred, Thoroughbred, and other light blood. Because of the premium on size in mules, height has been one of the important considerations in selecting jacks and jennets, and it is recorded in the pedigree studbooks.

It is widely recognized that mules are almost always sterile, and for this reason matings intended to produce a desired type must be made by the intelligent selection of jacks and mares of the right type. The few authentic cases of fertile mare mules [2] are of great scientific interest, but the high percentage of sterility is a serious obstacle to progress in breeding such animals, though the subject deserves investigation.

The ideal in jacks and jennets has so far been mainly concerned with height and large smooth bone, with some attention to action and straightness of legs. American mule breeders have achieved remarkable success in producing probably the best mules in the world, but the supply of good jack stock has diminished to such an extent that importation has again been resumed after a lapse of 25 years.

In performance tests with the dynamometer, mules have been disappointing by comparison with horses, although, like horses, they have demonstrated their tremendous reserve of power. At Fort Des Moines, Iowa, in 1924, a team of four Army mules, hitched tandem in two pairs, developed a tractive pull of 2.74 horsepower per mule as against 6.97 horsepower per horse for a six-horse team of horses of similar size. The mules pulled so slowly that they were unable to produce continuous motion over the required distance of 27½ feet for a large proportion of the heavy loads they could start. This again demonstrates the ineffectiveness of the dynamometer, as now used, to measure the ability of animals to endure a hard day's work. The mule, moreover, is phlegmatic and a creature of great stubbornness. He will not do his best without strenuous urging, and he will work harder in fear of the whip than under its sting. In all official pulling contests, all types of urging by drivers, such as use of whips and shouting, are prohibited.

[2] See Unusual Possibilities in Breeding, p. 183.

Superb Breeding Material, Awaiting a Greater Background of Knowledge

FOR no other class of livestock do we have such a wealth of recorded achievement as for the horse. The greatest of his species have given us brilliant marks to shoot at, in performance, in the ability to transmit desirable characters, and in longevity. As with all livestock, the disappointing performances go largely unrecorded. Yet they occur, and many a great performer has been a failure when measured by his progeny.

The failures are apt to be laid at the door of the animal's germ plasm. It is the least visible thing about him and therefore the most safely blamed. But may not some of them have environmental causes? Possibly serious errors in early training or in feeding have disturbed or altered the function of a vital gland. Certainly the horse is a highly complicated mechanism, and consequently subject to derangement.

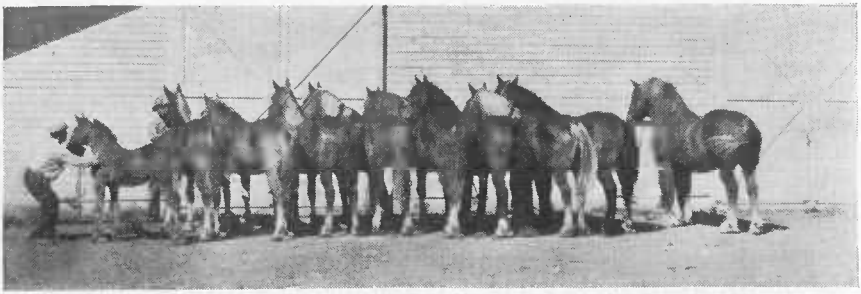


FIGURE 6.—A Belgian Draft stallion and his get, showing offspring of different ages left to right: Colt, 1-year-old, 2-year-old, 3-year-old, 4-year-old, 5-year-old, 6-year-old, 7-year-old, 8-year-old, and the sire, Rowdy, at extreme right. This illustration shows the uniformity of get of a "superior" sire from various matings, and the ability of this sire to transmit his good qualities to his offspring though the dams are of different breeding and types of conformation.

In many countries today the horse is receiving increasing attention from scientists. The endocrinologist especially is finding here a fertile field for experimentation. Most of his work to date, however, has been therapeutic, with no permanent hereditary effect. Unless he coordinates his work with that of the geneticist, some of his effort will tend to perpetuate undesirable germ plasm, and much of it will fail to improve the horse's inheritance. The same hormone that is used to extend the fertile life period of a great sire for which we have a progeny test and which has demonstrated longevity, will enable another sire with inherent tendencies toward sterility or other shortcomings to perpetuate his weakness in offspring.

Economic depression has emphasized anew the basic reliability and flexibility of animal horsepower for many types of farm work and the importance of breeding for better performance. The military depart-

ments of many nations are giving increased attention to improvement in saddle and artillery types. The field of sport is making ever-increasing and well-endowed demands of the horse, especially running breeds and polo types.

When the science of animal genetics has a background of greater experience, and when it reaches the point where it is eager to test its theories on a species of amazingly varied kinds and degrees of performance—some exactly measurable, others difficult if not impossible to define and measure accurately—the horse will offer excellent raw material.

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Appendix

Some Workers Identified With Horse Improvement at State and Federal Agricultural Experiment Stations and Other Institutions

At State agricultural experiment stations:
- California, Berkeley: C. W. Howell.
- California, Pomona: H. H. Reese.
- Connecticut, Storrs: H. L. Garrigus.
- Georgia, Athens: M. P. Jarnagin.
- Illinois, Urbana: J. L. Edmonds.
  C. W. Crawford.
- Indiana, Lafayette: R. B. Cooley.
  P. T. Brown.
- Iowa, Ames: A. B. Caine.
  J. L. Lush.
- Kansas, Manhattan: C. W. McCampbell.
- Kentucky, Lexington: W. W. Dimock.
  W. S. Anderson.
- Michigan, East Lansing: R. S. Hudson.
- Minnesota, St. Paul: W. H. Peters.
  A. L. Harvey.
- Missouri, Columbia: E. A. Trowbridge.
- Montana, Bozeman: D. W. Chittenden.
- New York, Ithaca: M. W. Harper.
- Ohio, Columbus: D. J. Kays.
- Oklahoma, Stillwater: W. L. Blizzard.
- Oregon, Corvallis: B. W. Rodenwold.
- Texas, College Station: D. W. Williams.
- Wisconsin, Madison: J. G. Fuller.

At other institutions:
- United States Remount Service, Fort Douglas, Utah: G. A. Bell.
- Carnegie Institution of Washington: H. H. Laughlin.

United States Department of Agriculture:
- United States Morgan Horse Farm, Middlebury, Vt.: E. B. Krantz.
- United States Range Livestock Experiment Station, Miles City, Mont.: E. B. Osborn.
- Bureau of Animal Industry, Washington, D. C.: J. O. Williams, S. R. Speelman.